



# UPPER RAPPAHANNOCK RIVER BASIN BACTERIA TMDL DEVELOPMENT

Virginia Department of Environmental Quality  
Rappahannock-Rapidan Regional Commission  
Engineering Concepts, Inc.

TECHNICAL ADVISORY COMMITTEE MEETING  
February 27, 2007



# TMDL DEVELOPMENT PROCESS

## ● WATERSHED HISTORY

- Characterize watershed and identify critical contamination conditions

## ● SOURCE ASSESSMENT

- Identify and quantify pollutant sources

## ● MODELING

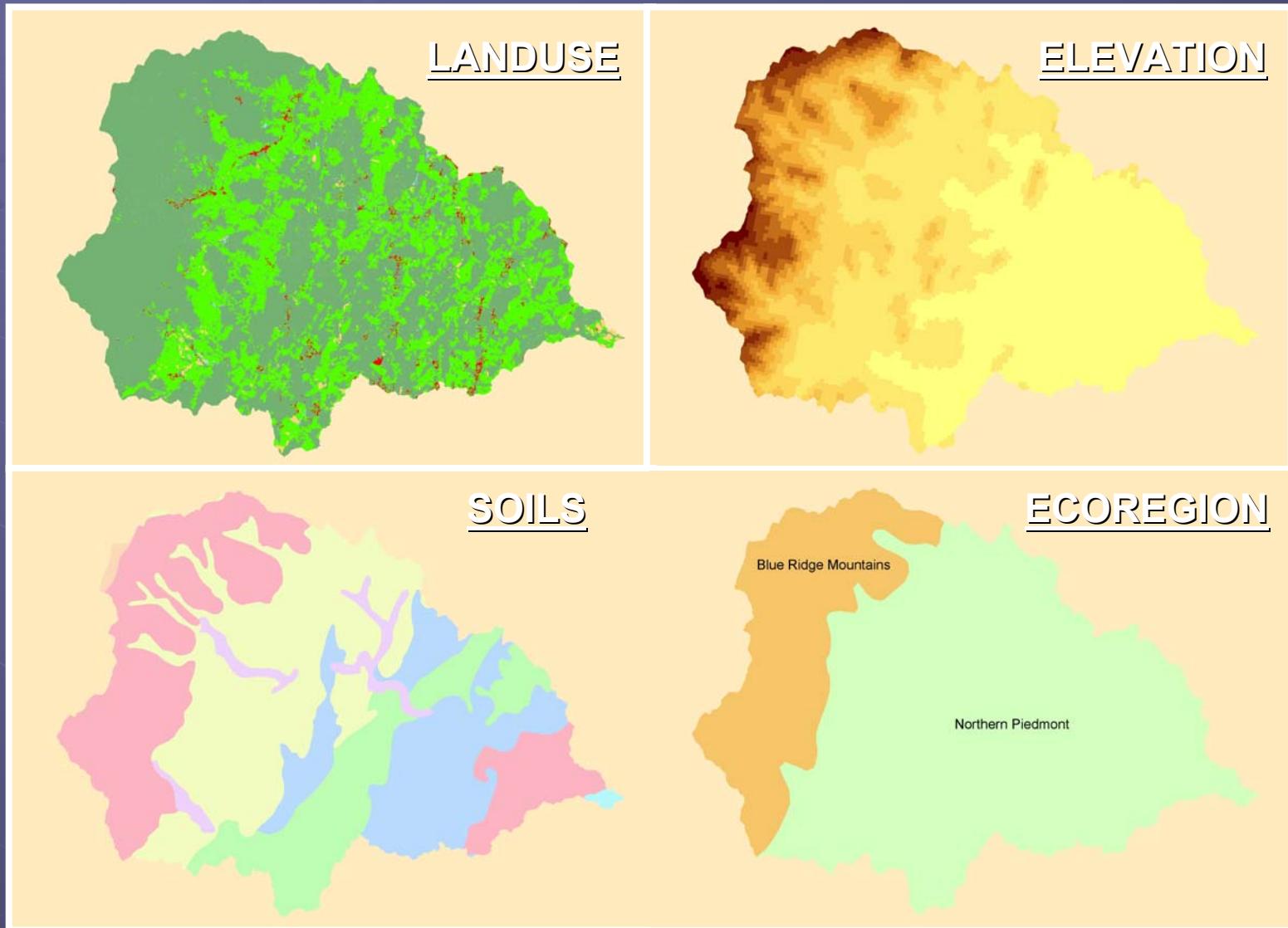
- Link pollutant sources to stream water quality

## ● ALLOCATION

- Develop and evaluate allocation scenarios

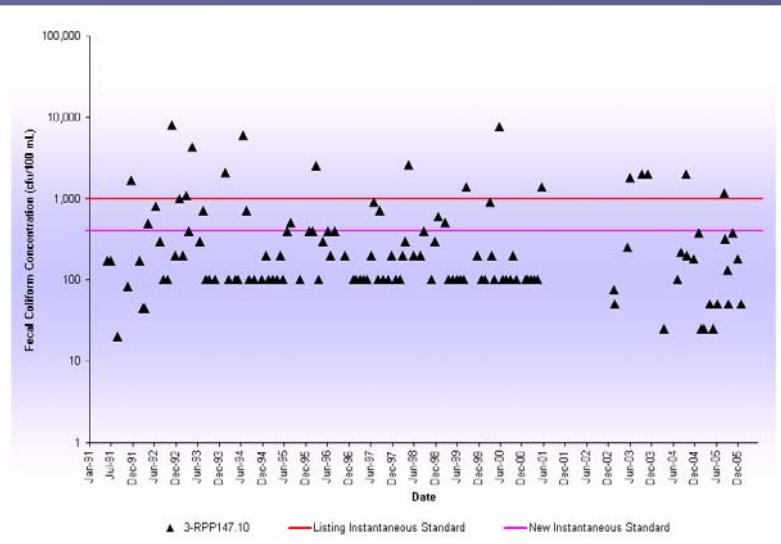


# WATERSHED HISTORY

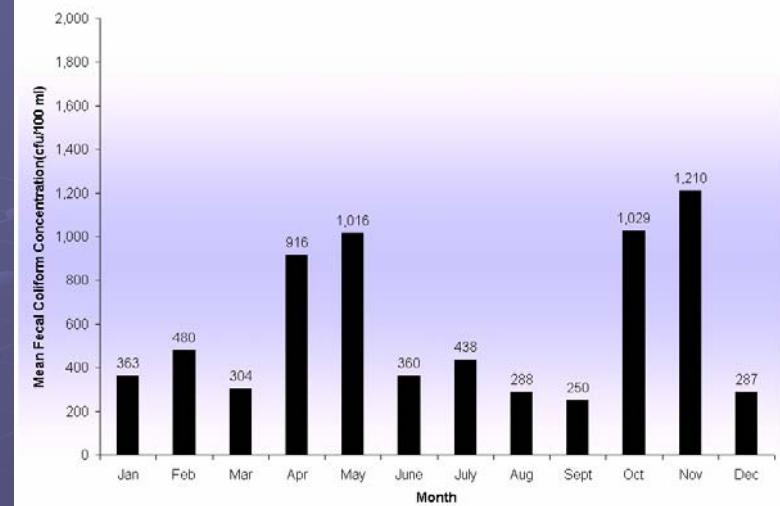




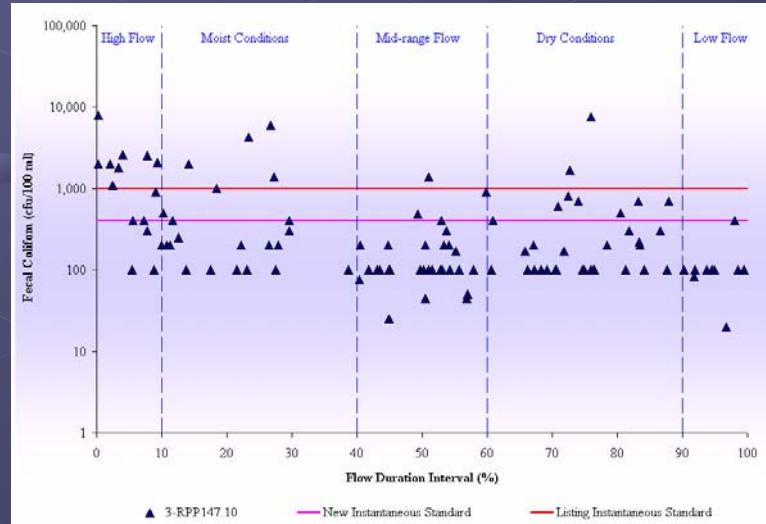
# WATERSHED HISTORY



## TIMESERIES



## SEASONALITY



## BACTERIA VS. FLOW



# SOURCE ASSESSMENT

Source Category	Source / Animal Type
Human and Pets	Permitted Discharges
	Straight Pipes
	Failing Septic Systems
	Biosolids Applications
	Dogs / Cats
Agricultural	Dairy & Beef Cattle
	Horses
	Sheep
	Poultry
	Deer
Wildlife	Raccoons
	Muskrats
	Beavers
	Turkeys
	Geese
	Ducks
	Bears



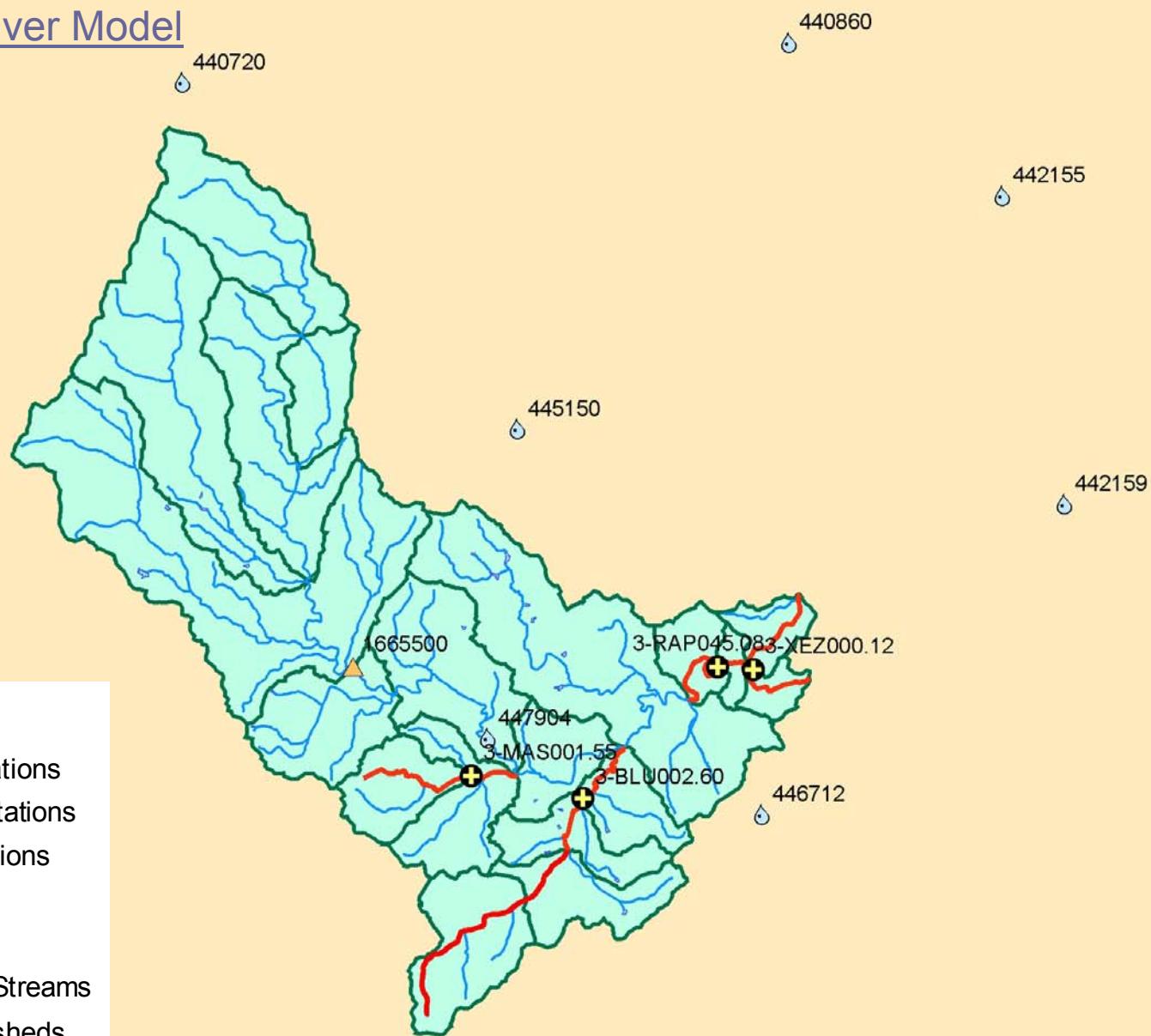
# MODELING

- Link pollutant sources to stream water quality
- Mathematically represent processes that are occurring in the watershed
- Processes
  - Hydrology – water balance
  - Water quality - pollutant fate and transport
- Accuracy Evaluation
  - Based on observed data
    - Flow: USGS gauge = model output
    - Bacteria: VADEQ station = model output



# MODELING

## Upper Rapidan River Model

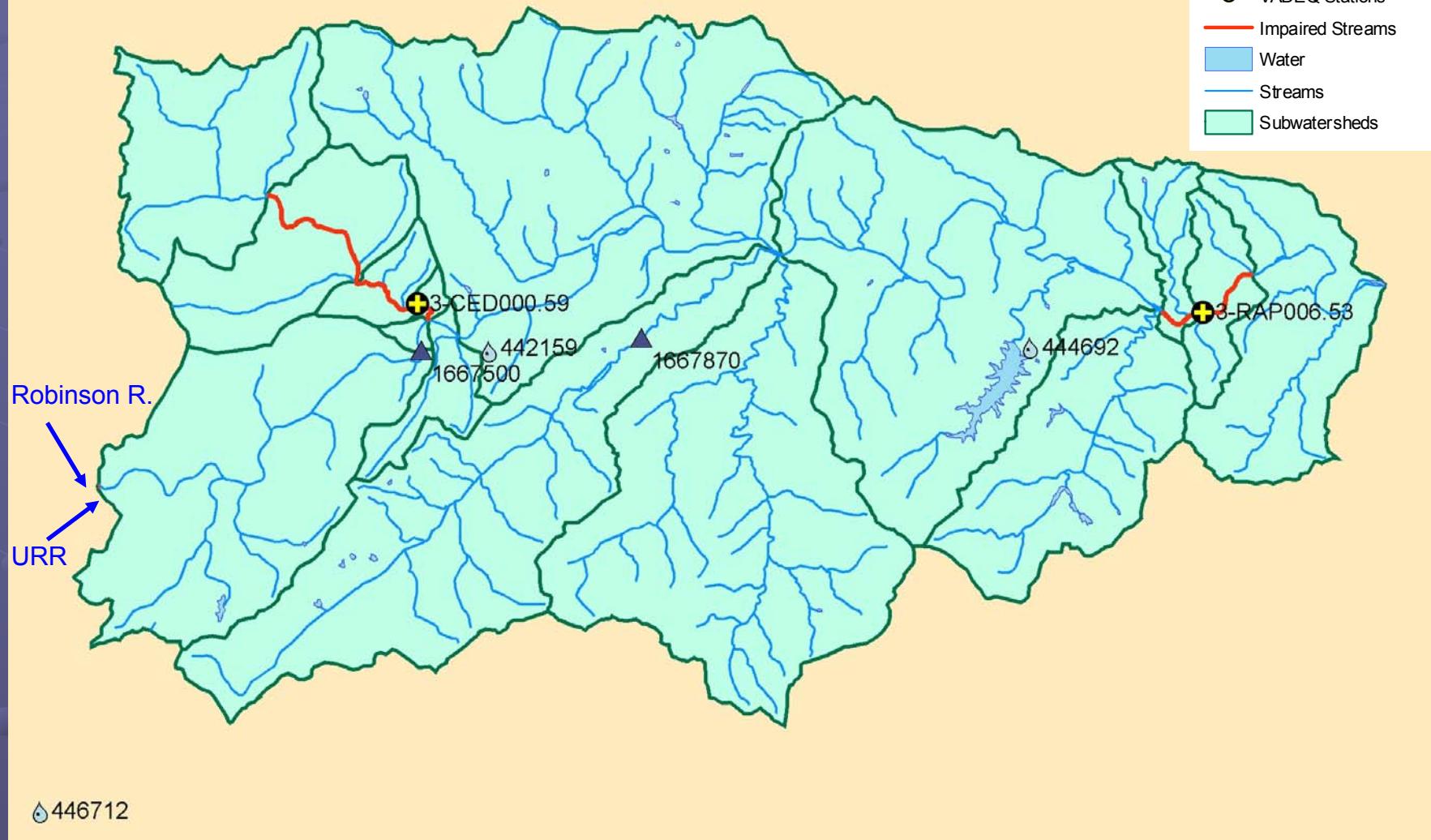




# MODELING

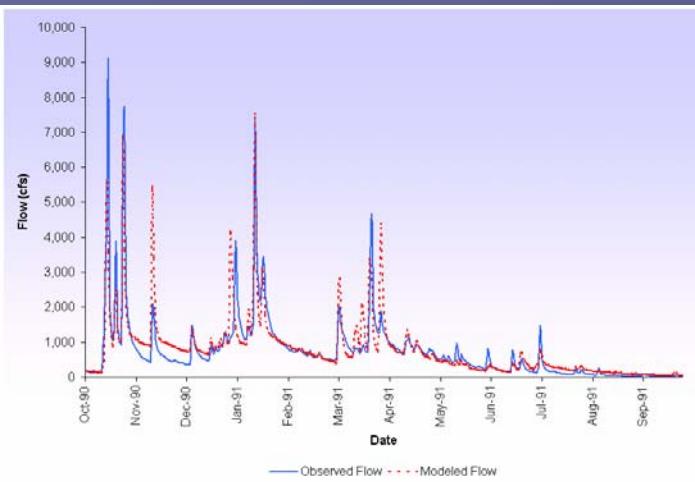
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## Lower Rapidan River Model





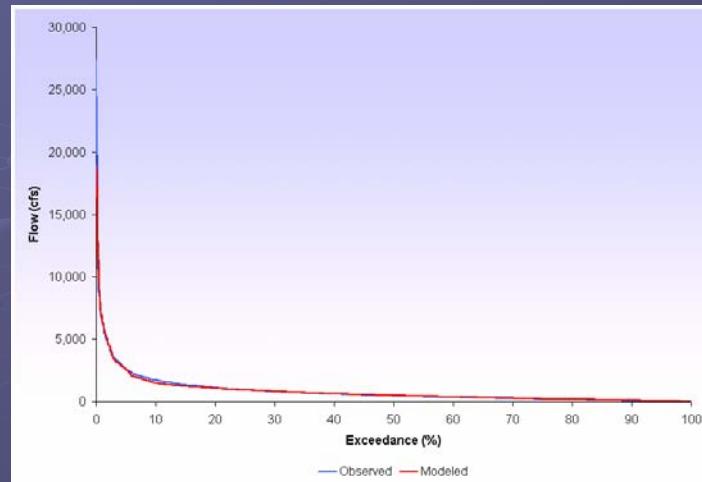
# HYDROLOGY CALIBRATION



Hydrograph Shape

Flow Pathway	Volume (in)	Volume (%)
Surface runoff	17	22
Interflow	15	19
Baseflow	46	59

Flow Partition



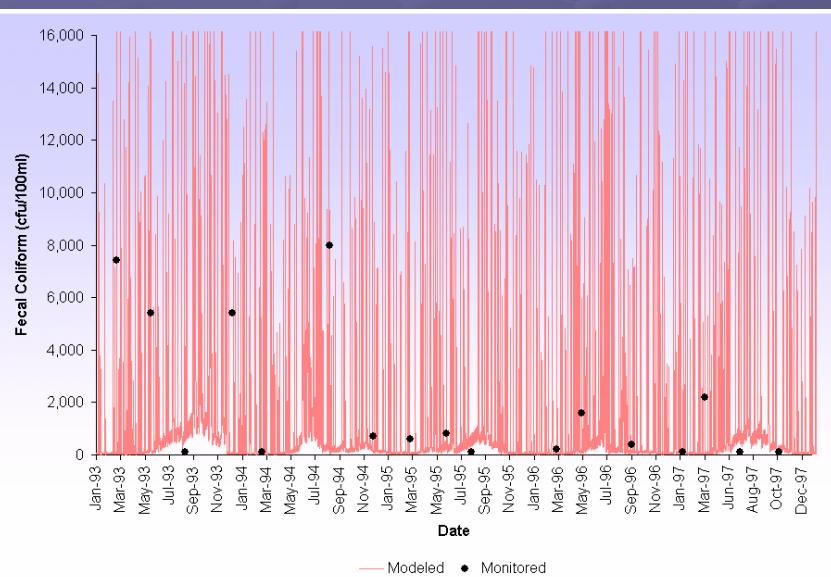
Flow Duration Curve

	Observed	Modeled	Criterion	Error
Total Runoff (in)	90.7	90.1	10%	-0.7%
Total of Highest 10% Flows (in)	40.3	39.4	15%	-2.3%
Total of Lowest 50% Flows (in)	11.9	13.0	10%	8.5%
Total Winter Runoff (in)	36.3	38.1	20%	4.7%
Total Summer Runoff (in)	11.1	11.4	20%	2.6%
Total Storm Runoff (in)	87.7	86.1	20%	-1.9%
Coefficient of Determination, $r^2$	0.83			

Summary Statistics



# WATER QUALITY CALIBRATION



## Qualitative Comparison

Parameter	Calibration	Validation
Geometric mean of VADEQ values (cfu/100mL)	599	213
Geometric mean of modeled values (cfu/100mL)	569	327
Fecal coliform instantaneous water quality standard (1,000 cfu/100mL) exceedance rate of VADEQ values (%)	35	21
Fecal coliform instantaneous water quality standard (1,000 cfu/100mL) exceedance rate of modeled values (%)	35	29
Fecal coliform instantaneous water quality standard (400 cfu/100mL) exceedance rate of VADEQ values (%)	53	21
Fecal coliform instantaneous water quality standard (400 cfu/100mL) exceedance rate of modeled values (%)	53	36

## Quantitative Comparison



# ALLOCATION

- Calculate design loads for point sources and existing loads for non-point sources
- Create load reductions scenarios controlling anthropogenic sources first
- Run model with scenarios
- Calculate geometric mean and instantaneous water quality standard (WQS) exceedance rate
- Select scenario with 0% geometric mean and instantaneous water quality WQS exceedance rate



# RAPIDAN RIVER ALLOCATION

Point Source	Permit #	Design Flow (MGD)	Existing Condition Load (cfu/yr)
Rapidan STP	VA0090948	0.600	1.66E+12
Greene County WTP	VA0051144	0.026	0.00E+00
Rapidan Baptist Camp and Conference Center	VA0060879	0.020	5.52E+10
Orange Town Water Treatment Plant	VA0053121	0.266	0.00E+00
Orange Town WWTP	VA0021385	3.000	8.29E+12
Spicers Mill STP	VA0092053	0.090	2.49E+11
Woodberry Forest School	VA0027839	0.039	1.08E+11



# RAPIDAN RIVER ALLOCATION

<b>Non-point Source</b>	<b>Existing Condition Load (cfu/yr)</b>
<b>Direct Deposition</b>	
Straight Pipes	3.18E+14
Livestock	1.84E+14
Wildlife	1.61E+14
<i>Total</i>	6.63E+14
<b>Land-based</b>	
Residential	4.05E+15
Cropland	3.86E+14
Pasture	1.79E+17
Forest	9.67E+14
<i>Total</i>	1.84E+17



# RAPIDAN RIVER ALLOCATION

Scenario Number	Percent Reduction in Fecal Coliform Loading from Existing Conditions							% Violations of E. coli WQS	
	Straight Pipes	Livestock DD	Wildlife DD	Residential	Cropland	Pasture	Forest	GM	Instant.
0	0	0	0	0	0	0	0	80.0	39.8
1	100	100	0	0	0	0	0	26.7	33.6
2	100	100	0	75	75	75	0	3.3	11.2
3	100	100	0	95	95	95	0	0.0	0.6
4	100	100	0	98	98	98	0	0.0	0.0
5	100	98	0	98	98	98	0	0.0	0.0



# RAPIDAN RIVER ALLOCATION

Facility Name	Permit #	Existing Condition Load (cfu/yr)	Loading Reduction (%)	Allocation Condition Load (cfu/yr)
Rapidan STP	VA0090948	1.66E+12	0	1.66E+12
Greene County WTP	VA0051144	0.00E+00	0	0.00E+00
Rapidan Baptist Camp and Conference Center	VA0060879	5.52E+10	0	5.52E+10
Orange Town Water Treatment Plant	VA0053121	0.00E+00	0	0.00E+00
Orange Town WWTP	VA0021385	8.29E+12	0	8.29E+12
Spicers Mill STP	VA0092053	2.49E+11	0	2.49E+11
Woodberry Forest School	VA0027839	1.08E+11	0	1.08E+11



# RAPIDAN RIVER ALLOCATION

Source	Existing Condition Load (cfu/yr)
<b>Direct Deposition</b>	
Straight Pipes	3.18E+14
Livestock	1.84E+14
Wildlife	1.61E+14
<i>Total</i>	<i>6.63E+14</i>
<b>Land-based</b>	
Residential	4.05E+15
Cropland	3.86E+14
Pasture	1.79E+17
Forest	9.67E+14
<i>Total</i>	<i>1.84E+17</i>

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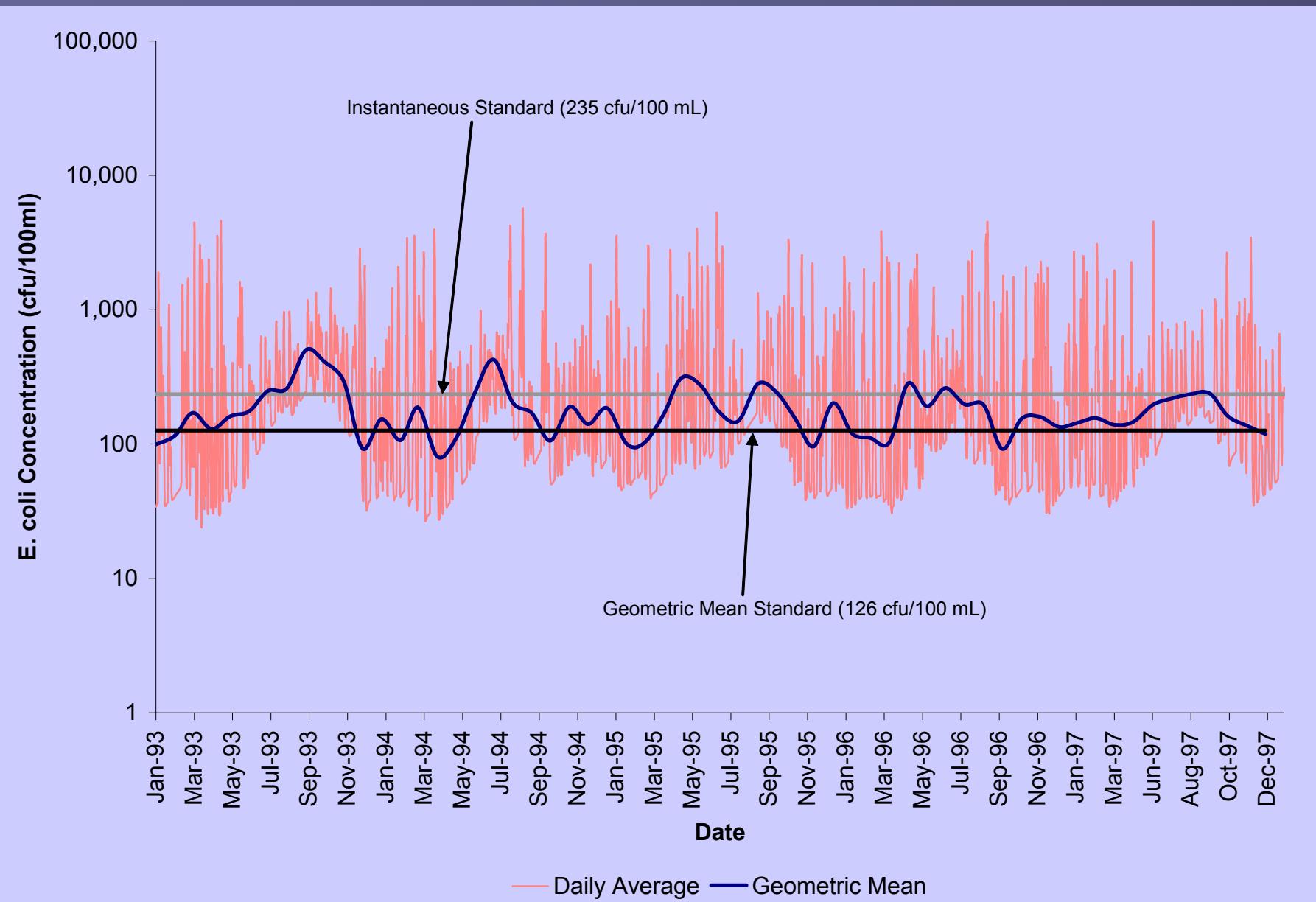
Scenario 5 Reduction (%)
100
98
0
98
98
98
0

=

Source	Allocation Condition Load (cfu/yr)
<b>Direct Deposition</b>	
Straight Pipes	0.00E+00
Livestock	3.68E+12
Wildlife	1.61E+14
<i>Total</i>	<i>1.65E+14</i>
<b>Land-based</b>	
Residential	8.10E+13
Cropland	7.72E+12
Pasture	3.58E+15
Forest	9.67E+14
<i>Total</i>	<i>4.64E+15</i>

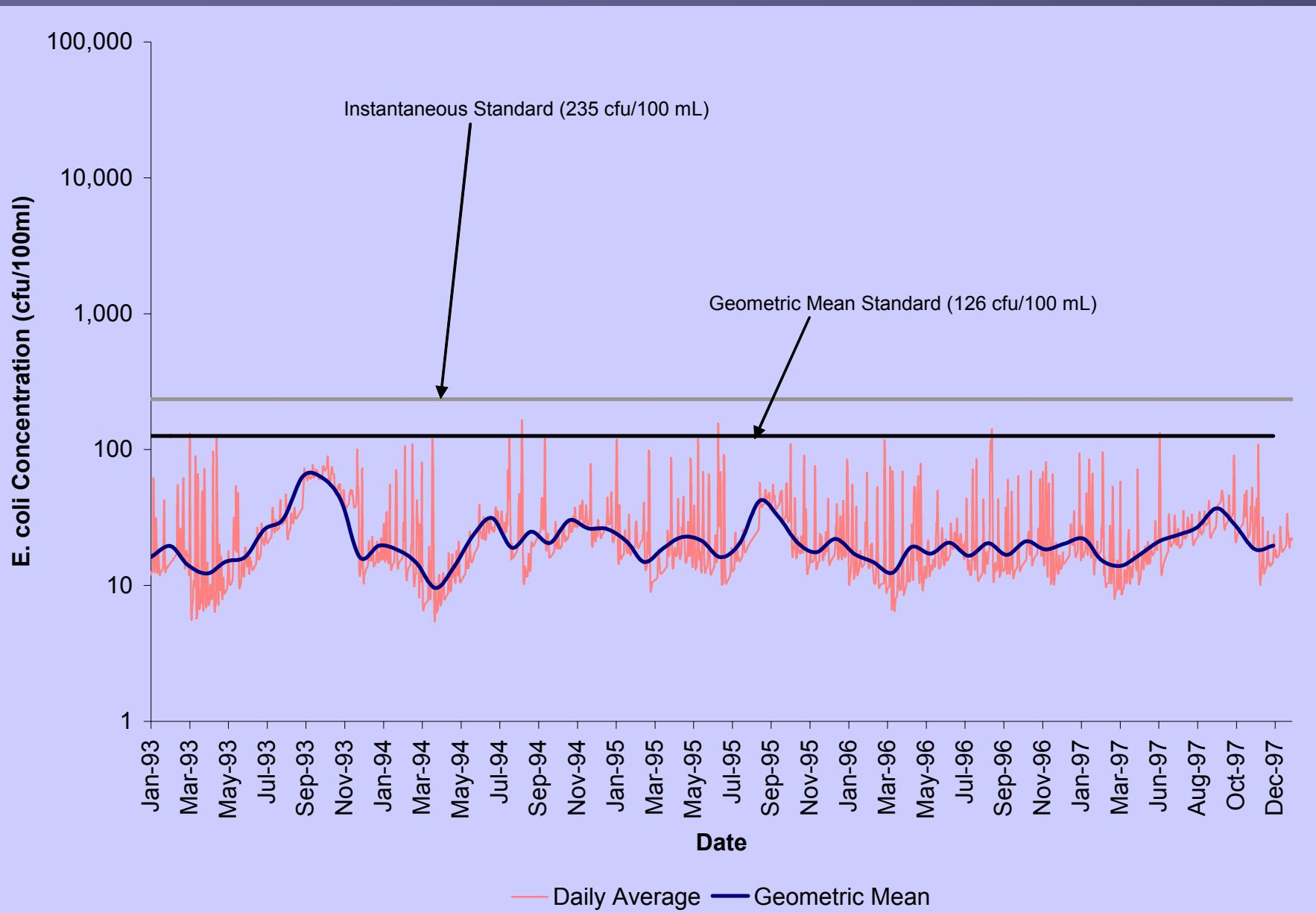


# RAPIDAN RIVER EXISTING CONDITIONS





# RAPIDAN RIVER ALLOCATION CONDITIONS





# ALLOCATION REDUCTIONS

Impairment	Percent Reduction in Fecal Coliform Loading from Existing Conditions						
	Straight Pipes	Livestock DD	Wildlife DD	Residential	Cropland	Pasture	Forest
Marsh Run (VAN-E13R-03)	100	98	0	98	98	98	0
Blue Run (VAN-E13R-01)	100	99	30	99	99	99	0
UT to Rappidan (VAN-E13R-04)	100	99	38	99	99	99	0
Rappidan River (VAN-E13R-02)	100	98	0	98	98	98	0
Cedar Run (VAN-E16R-01)	100	98	0	98	98	98	0
Rappidan River (VAN-E18R-01)	100	96	0	96	96	96	0



# IMPLEMENTATION PLAN DEVELOPMENT

- Next phase of TMDL process after USEPA TMDL approval
- Outlines plan to link load reductions specified in TMDL Development Study to corrective actions (e.g., BMPs)
- Project schedule governed by criteria outlined by VADCR
  - Local interest one of the criteria



# TMDL IMPLEMENTATION

- Stage I:

- Attain water quality standard enabling delisting of streams from Section 303(d) List of Impaired Waters

- Stage II:

- Attainment of TMDL source load allocations required under WQMIRA and USEPA to receive Section 319 grant funds to fund implementation



# STAGE 1 IMPLEMENTATION

- Calculate design loads for point sources and existing loads for non-point sources
- Create load reductions scenarios controlling anthropogenic sources only
  - Goal: 0% reduction in wildlife DD and forest land use
- Run model with scenarios
- Calculate instantaneous WQS exceedance rate
- Select scenario with less than 10% instantaneous WQS exceedance rate



# STAGE 1 REDUCTIONS

Impairment	Percent Reduction in Fecal Coliform Loading from Existing Conditions						
	Straight Pipes	Livestock DD	Wildlife DD	Residential	Cropland	Pasture	Forest
Marsh Run (VAN-E13R-03)	100	75	0	75	75	75	0
Blue Run (VAN-E13R-01)	100	90	0	78	78	78	0
UT to Rapidan (VAN-E13R-04)	100	75	0	75	75	75	0
Rapidan River (VAN-E13R-02)	100	95	0	78	78	78	0
Cedar Run (VAN-E16R-01)	100	89	0	89	89	89	0
Rapidan River (VAN-E18R-01)	100	75	0	46	46	46	0



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